

# Import-Export Linkages as a Channel for Exchange Rate Hedging

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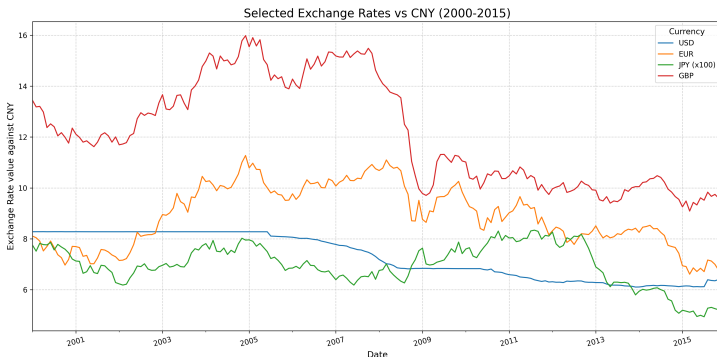
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# Outline

- 1 Introduction
- 2 Empirical Facts
- 3 Model
- 4 Quantitative Analysis
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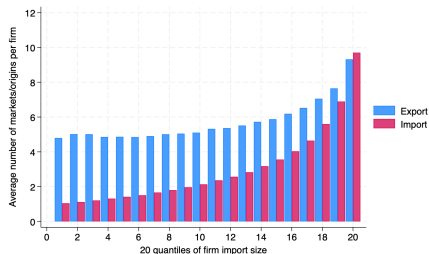
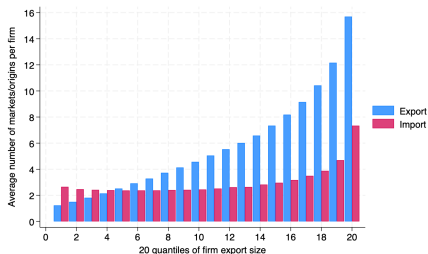
# Exchange Rate Fluctuations



**Figure:** Nominal exchange rate changes of USD, Euro, JPY and GBP against CNY

- Exchange rate is volatile and persistent (Itskhoki and Mukhin, 2021).
- Exchange rates of RMB vs major currencies show different trends.

# Export Markets and Import Origins



- Large exporters are often large importers (Amiti, Itskhoki and Konings, 2014).
- Export and import will enhance each other (Li et al., 2024).
- Large exporters export to more markets and import from more origins (left).
- Large importers import from more origins and export to more markets (right).

# Exchange Rate Risk Hedging

- **Background:** limited financial hedging in emerging markets
  - In China and other emerging markets, limited access to FX derivatives (and/or high costs) constrain financial hedging for most firms.
  - A few percentage points of exchange rate fluctuations can wipe out an exporter's profit margins  $\Rightarrow$  **firms need to hedge in other ways!**
- **Natural hedging:** import–export linkages can offset currency risks.
  - Conventional trade models either do not consider hedging (treat risk ex post) or only consider complete financial hedging. [▶ Financial vs Natural](#)
  - This paper embeds natural hedging (non-financial hedging) in trade.
- Opposite effects of exchange rates: **price effect** vs **cost effect**
  - e.g. if there is a home currency depreciation (RMB vs USD)
  - **Price**  $\rightarrow$  lower local currency price (or higher producer currency price).
  - **Cost**  $\rightarrow$  imported inputs more expensive, higher costs.
- Motivation: *multi-country trade network vs multilateral exchange rate shocks*

# What I Do and Find

- **Empirical:** Three facts from Chinese customs data (2000–2015).
  - Two-way traders are less sensitive to bilateral exchange rates.
  - Similar network (greater overlap) of import origins and export markets reduces sensitivity to bilateral exchange rates.
  - Firm-effective exchange rate (FEER) shocks have opposite effects:
    - Export-weighted FEER  $\uparrow \Rightarrow$  export value  $\uparrow$ ;
    - import-weighted FEER  $\uparrow \Rightarrow$  export value  $\downarrow$ .
    - The joint effect is weaker for two-way traders.
- **Model (risk-neutral  $\rightarrow$  risk-averse):**
  - Risk-neutral model: bilateral exchange rate shocks affect revenues and input costs in different directions  $\rightarrow$  **mechanic** hedging.
  - Risk-averse extension: firms adjust prices and sourcing to reduce profit variance at the cost of expected profit  $\rightarrow$  **strategic** hedging.
- **Quantitative:**
  - Stronger risk aversion and mixed invoicing leads to better hedging;
  - Larger initial import–export overlap leads to better hedging;
  - Hedging will adjust when exchange rate environment changes.

# Connection to Literature

- **Import–export linkages:** Large exporters are large (and diverse) importers; imported inputs shape shock transmission.
  - Amiti, Itskhoki and Konings (2014), Gopinath and Neiman (2014), Halpern, Koren and Szeidl (2015), Blaum (2024), Li et al. (2024).
  - My paper: import-export linkages can reduce exchange rate risk.
- **Hedging of exchange rate risk:**
  - Financial hedging: Allayannis and Ofek (2001), Allayannis and Weston (2001), Salomao and Varela (2022);
  - Non-financial hedging: Raddatz (2011), Fauceglia, Shingal and Wermelinger (2014), Alfaro, Calani and Varela (2021).
  - My paper: a new non-financial hedging channel via trade network
- **ER pass-through:** Pricing-to-market frameworks connect invoicing currency choices to short-run responses to exchange rate shocks.
  - Gopinath and Rigobon (2008), Gopinath, Itskhoki and Rigobon (2010), Devereux, Dong and Tomlin (2017).
  - My paper: invoicing currency choice affects natural hedging.

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# Data and Measurements

We combine granular trade data and international macro statistics.

- ① Chinese Customs Trade Statistics (CCTS)
    - Source: General Administration of Customs of China
    - Coverage: from 28,000 to 186,000 firms, 2000-2015
  - ② International Financial Statistics (IFS) from IMF
    - Exchange rates and inflation; 194 countries since 1948.
  - ③ Penn World Table (PWT)
    - Country-level macro variables; 183 countries, 1950-2019
- Bilateral real exchange rates:  $RER_{kt} = NER_{kt} \times \frac{CPI_{kt}}{CPI_{it}}$
  - Firm effective (value-weighted) exchange rates:

$$\Delta FEEER_{ft}^X = \sum_i \chi_{fkt}^X \Delta RER_{kt} \quad , \quad \Delta FEEER_{ft}^M = \sum_j \chi_{fjt}^X \Delta RER_{jt} \quad (1)$$

$$\text{where } \chi_{fkt}^X = \frac{V_{fkt}^X}{\sum_{k' \in \mathcal{K}} V_{fk't}^X}, \quad \chi_{fjt}^M = \frac{V_{fjt}^M}{\sum_{j' \in \mathcal{J}} V_{fj't}^M}.$$

# Empirical Strategy

- **Question:** does the response of exports to exchange rate shocks depend on the firm-level and firm-country-level export-import linkages?
- The baseline specifications:

$$\Delta V_{fkt}^X = \beta_1 \Delta RER_{kt} + \beta_2 \Delta RER_{kt} \times \tilde{s}_{f(k)t-1}^M + \gamma Z_{ft-1} + \eta G_{kt} + \delta_f + \epsilon_t \quad (2)$$

$$\Delta V_{ft}^X = \beta_1 \Delta FEER_{ft}^X + \beta_2 \Delta FEER_{ft}^M + \gamma Z_{ft-1} + \delta_f + \epsilon_t \quad (3)$$

- $V_{fkt}^X$ : firm-country-level export value change;
- $\tilde{s}_{f(k)t-1}^M$ : trade linkage terms, including two-way indicators  $TW_{f(k)t-1}$ , lag import intensity  $s_{f(k)t-1}^M$  and import-export similarity  $Jaccard_{ft}$  and  $\phi_{ft}$ .
- $Z_{ft-1}$ : a vector of firm-level lagged control variables;
- $G_{kt}$ : country-level gravity controls;
- $\delta_f$ : firm-level (time-invariant) fixed effects;

# Fact 1: Firm-level Two-way Traders

**Table:** Firm-level Two-way Linkages and Export Value Elasticity

Sample Dependent Var	(1)	(2) All Exporters	(3) $\Delta \ln V_{fkt}^X$	(4)	(5) Two-way Traders	(6)
$\Delta \ln RER_{kt}$	0.309*** (0.078)	0.346*** (0.084)	0.502*** (0.075)	0.651*** (0.077)	0.511*** (0.092)	0.623*** (0.118)
$\Delta \ln RER_{kt} \times TW_{ft-1}$			-0.533*** (0.117)	-0.747*** (0.121)		
$\Delta \ln RER_{kt} \times s_{ft-1}^M$					-0.963*** (0.303)	-1.318*** (0.367)
$\Delta \ln RGDP_{kt}$	1.386*** (0.212)	2.102*** (0.271)	1.358*** (0.210)	2.076*** (0.266)	1.440*** (0.246)	2.148*** (0.312)
Lag Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Gravity Controls	Yes	No	Yes	No	Yes	No
Firm-country FE	No	Yes	No	Yes	No	Yes
Firm FE	Yes	No	Yes	No	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5019959	4375637	5019959	4375637	1492001	1305681
$R^2$	0.117	0.196	0.117	0.196	0.102	0.187

Notes: The dependent variables are firm-country-level export value changes. \*, \*\*, and \*\*\* indicate significance at 10%, 5%, and 1% levels, respectively.

# Fact 1: Market-specific Two-way Traders

**Table:** Market-specific Two-way Linkages and Export Value Elasticity

Sample Dependent Var	(1)	(2) Two-way Traders $\Delta \ln V_{fkt}^X$	(3)	(4)
$\Delta \ln RER_{kt}$	0.450*** (0.079)	0.502*** (0.084)	0.938*** (0.109)	1.229*** (0.162)
$\Delta \ln RER_{kt} \times TW_{fkt-1}$	-0.472*** (0.106)	-0.512*** (0.127)		
$\Delta \ln RER_{kt} \times s_{fkt-1}^M$			-4.440*** (0.574)	-5.700*** (0.802)
$\Delta \ln RGDP_{kt}$	1.423*** (0.243)	2.102*** (0.310)	1.322*** (0.248)	1.882*** (0.319)
Lag Firm Controls	Yes	Yes	Yes	Yes
Gravity Controls	Yes	No	Yes	No
Firm FE	Yes	No	Yes	No
Firm-country FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1492001	1305681	1492001	1305681
$R^2$	0.102	0.187	0.105	0.190

Notes: The dependent variables are firm-country-level export value changes. \*, \*\*, and \*\*\* indicate significance at 10%, 5%, and 1% levels, respectively.

- The sensitivity of export values to bilateral exchange rate shocks is significantly lower for both firm-level and firm-country-level two-way traders.

## Fact 2: Network Similarity

**Table:** Firm-level Network Similarity and Export Value Elasticity

Sample Dependent Var	(1)	(2) Two-way Traders $\Delta \ln V_{jkt}^X$	(3)	(4)
$\Delta \ln RER_{kt}$	0.420*** (0.125)	0.484*** (0.125)	0.541*** (0.161)	0.651*** (0.163)
$\Delta \ln RER_{kt} \times Jaccard_{ft-1}$	-0.536* (0.308)	-0.673** (0.315)		
$\Delta \ln RER_{kt} \times \phi_{ft-1}$			-0.594** (0.298)	-0.777** (0.315)
$\Delta \ln RGDP_{kt}$	1.435*** (0.248)	2.138*** (0.315)	1.435*** (0.248)	2.138*** (0.315)
Lag Firm Controls	Yes	Yes	Yes	Yes
Gravity Controls	Yes	No	Yes	No
Firm FE	Yes	No	Yes	No
Firm-country FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1492001	1305681	1492001	1305681
$R^2$	0.102	0.187	0.102	0.187

Notes: The dependent variables are firm-country-level export value changes. \*, \*\*, and \*\*\* indicate significance at 10%, 5%, and 1% levels, respectively.

- Conditional on two-way trade, firms with similar import and export countries are significantly less sensitive to bilateral exchange rate shocks.

# Fact 3: Firm-Effective Exchange Rates

**Table:** Firm Effective Exchange Rates and Export Value Elasticity

Sample Dependent Var	(1)	(2) All Exporters	(3) $\Delta \ln V_{ft}^X$	(4)	(5) Two-way Traders	(6)
$\Delta \ln FEER_{ft}^X$	0.165*** (0.029)		0.421*** (0.029)	0.036 (0.057)		0.108* (0.063)
$\Delta \ln FEER_{ft}^M$		-1.130*** (0.035)	-1.256*** (0.036)		-0.100** (0.047)	-0.144*** (0.052)
Lag Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1285518	1285518	1285518	344163	344163	344163

Notes: The dependent variables are firm-level export value changes. Column (1)-(3) include all exporters, column (4)-(6) include two-way traders who both export and import. \*, \*\*, and \*\*\* indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors are clustered at the firm level and country-year level.

- Value-weighted firm effective exchange rate shocks have opposite effects:
  - export FEER is positively correlated with export value
  - import FEER is negatively correlated with export value
  - when both FEERs enter, the magnitudes are weaker for two-way traders.

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# Environment & Technology

- N countries indexed by  $i$  (host),  $j$  (import origin) and  $k$  (export destination)
- Consumer utility in the CES objective

$$U_i = \left( \int_{\omega \in \Omega_i} q_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1 \quad (4)$$

- Cobb-Douglas production uses labor  $L$ , material inputs  $X$  and technology  $\varphi$

$$y_i(\omega) = \varphi(\omega) L_i^{1-\alpha} X_i^\alpha \quad (5)$$

- Input bundle nests a two-layer CES between domestic and imported inputs:

$$X_i = \left[ X_{D,i}^{\frac{\epsilon-1}{\epsilon}} + X_{M,i}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}, \quad X_{M,i} = \left( \sum_{j \in \mathcal{J}} X_{ij}^{\frac{\kappa-1}{\kappa}} dj \right)^{\frac{\kappa}{\kappa-1}}, \kappa > 1 \quad (6)$$

- Unit production cost under constant return to scale is:

$$c_i(\omega) = \varphi(\omega)^{-1} \alpha^{-\alpha} (1-\alpha)^{\alpha-1} w_i^{1-\alpha} P_{X,i}(\omega)^\alpha \quad (7)$$

# Export Pricing Decision

- Dixit–Stiglitz demand in both domestic market  $i$  and foreign markets  $k$ .
- The total export revenue in market  $k$  is a mix of PCP and LCP:

$$R_{ki} = \lambda R_{ki}^{PCP} + (1 - \lambda) R_{ki}^{LCP} = \lambda e_{ik}^{\sigma} B_{ki}^{PCP} + (1 - \lambda) e_{ik} B_{ki}^{LCP} \quad (8)$$

where  $B_{ki}^{PCP} \equiv \left(\frac{\bar{P}_{ki}^i}{P_k}\right)^{1-\sigma} \frac{S_k}{P_k}$  and  $B_{ki}^{LCP} \equiv \left(\frac{\bar{P}_{ki}^k}{P_k}\right)^{1-\sigma} \frac{S_k}{P_k}$ .

- The optimal export share to country  $k$  is:

$$\chi_{ki}^X \equiv \frac{R_{ki}}{R_i^X} = \frac{\lambda e_{ik}^{\sigma} B_{ki}^{PCP} + (1 - \lambda) e_{ik} B_{ki}^{LCP}}{\sum_{k'} [\lambda e_{ik'}^{\sigma} B_{k'i}^{PCP} + (1 - \lambda) e_{ik'} B_{k'i}^{LCP}]} \quad (9)$$

# Import Sourcing Decision

- The intermediate input price index  $P_X$ :

$$P_{X,i} = (P_{D,i}^{1-\varepsilon} + P_{M,i}^{1-\epsilon})^{\frac{1}{1-\epsilon}}, \quad P_{M,i} = \left( \sum_{j \in \mathcal{J}} p_{ij}^{1-\kappa} dj \right)^{\frac{1}{1-\kappa}} \quad (10)$$

- Import share from country  $j$  over total imported input:

$$\chi_{ij}^M = \frac{p_{ij} \left( \frac{p_{ij}}{P_{M,i}} \right)^{-\kappa}}{\sum_{j' \in \mathcal{J}} p_{ij'} \left( \frac{p_{ij'}}{P_{M,i}} \right)^{-\kappa}} = \frac{(p_{ij}^* e_{ij})^{1-\kappa}}{\sum_{j' \in \mathcal{J}} (p_{ij'}^* e_{ij'})^{1-\kappa}} \quad (11)$$

- Overall input price  $P_X = P_D [1 + A^{\epsilon-1}]^{\frac{1}{1-\epsilon}}$ 
  - $A_i = P_{D,i}/P_{M,i} \rightarrow$  cost advantage from cheaper imported inputs.
- The optimal share of input expenditure on imported inputs (import intensity):

$$s_i^M = \frac{A_i^{\epsilon-1}}{1 + A_i^{\epsilon-1}}, \quad 0 < s_i^M < 1 \quad (12)$$

# Static Exchange Rate Pass-Through

- Exchange elasticities of cost  $c_i$  and bilateral export price  $p_{ki}$ :

$$\varepsilon(c_i, e_{il}) = \alpha s_i^M \chi_{il}^M > 0 \quad (13)$$

$$\varepsilon(p_{ki}, e_{il}) = \lambda \mathbf{1}\{k = l\} + \alpha s_i^M \chi_{il}^M \quad (14)$$

- Exchange elasticities of bilateral export revenue  $R_{ki}$  and total revenue  $R_i^X$ :

$$\varepsilon(R_{ki}, e_{il}) = \underbrace{[\lambda\sigma + 1 - \lambda]\mathbf{1}\{k = l\}}_{\text{price effect}(+)} + \underbrace{(1 - \sigma)\alpha s_i^M \chi_{il}^M}_{\text{cost effect}(-)} \quad (15)$$

$$\varepsilon(R_i^X, e_{il}) \equiv \underbrace{[\lambda\sigma + 1 - \lambda]\chi_{li}^X}_{\text{price effect}(+)} + \underbrace{(1 - \sigma)\alpha s_i^M \chi_{il}^M}_{\text{cost effect}(-)} \quad (16)$$

- Bilateral exchange rate shocks will have opposite impacts on price and cost!

# Static Intensive Margin Adjustments

- Exchange rate elasticity of import intensity  $s_i^M$  and export intensity  $s_i^X$ :

$$\varepsilon(s_i^M, e_{il}) = (1 - \epsilon)(1 - s_i^M)\chi_{il}^M < 0 \quad (17)$$

$$\varepsilon(s_i^X, e_{il}) = \frac{\partial \ln s_i^X}{\partial \ln e_{il}} = \sigma(1 - s_i^X)\chi_{li}^X > 0 \quad (18)$$

- Exchange rate elasticity of import share  $\chi_{ij}^M$ , and export share  $\chi_{ki}^X$ :

$$\varepsilon(\chi_{ij}^M, e_{il}) = (1 - \kappa)(\mathbf{1}\{j = l\} - \chi_{il}^M) \rightarrow \text{direct} < 0, \quad \text{indirect} > 0 \quad (19)$$

$$\varepsilon(\chi_{ki}^X, e_{il}) = (\lambda\sigma + 1 - \lambda)(\mathbf{1}\{k = l\} - \chi_{li}^X) \rightarrow \text{direct} > 0, \quad \text{indirect} < 0 \quad (20)$$

- Bilateral exchange rate shocks will lead to intensive margin adjustments.

# Profit Exposure Decomposition

- Random walk with covariance:  $\varepsilon_t^e \sim \mathcal{N}(\mathbf{0}, \Sigma^e)$
- Decompose profit deviation into revenue and cost deviations ( $\tilde{x} = x - \mathbb{E}[x]$ ):

$$\tilde{\pi}_i = \tilde{R}_{ii} + \sum_k \tilde{R}_{ki} - \tilde{C}_{M,i} \quad (21)$$

- Decompose profit deviation into exposures to bilateral exchange rate shocks:

$$\tilde{\pi}_i = \sum_l u_{il} \Delta e_{il} \quad (22)$$

→ Each bilateral exposure can be decomposed into three parts

$$u_{il} = \underbrace{a_{il}}_{\text{domestic sales}} + \sum_k \underbrace{b_{il,k}}_{\text{export sales}} - \underbrace{c_{il}}_{\text{import costs}} \quad (23)$$

- $\mathbf{u}_i$  encodes multilateral exposure shaped by structural parameters.

$$\mathbf{u}_i = (u_{i1}, u_{i2}, \dots, u_{iN})^\top = (a_{i1} + \sum_k b_{i1}^k - c_{i1}, \dots, a_{iN} + \sum_k b_{iN}^k - c_{iN})^\top \quad (24)$$

# Optimization under Risk Aversion

- Constant absolute risk aversion (CARA) with parameter  $\gamma > 0$ :

$$J = \underbrace{\mathbb{E}[\pi_i]}_{\text{Expected Profit}} - \underbrace{\frac{\gamma}{2} \cdot \text{Var}(\pi_i)}_{\text{Risk Loss}} \quad (25)$$

- Profit variance in matrix form:  $\text{Var}(\pi_i) = \mathbf{u}_i^\top \Sigma^e \mathbf{u}_i$ .
- First-order conditions (FOCs) of intensive margin decisions:

$$\frac{\partial \mathbb{E}[\pi_i]}{\partial \theta} = \gamma \left( \frac{\partial u_i}{\partial \theta} \right)^\top \Sigma^e \mathbf{u}_i \quad (26)$$

- What happen to firms' intensive margin decision if they are risk averse?
  - ① export price premium: export more or less by charging a different markup
  - ② import sourcing shift: import more or less by applying a "shadow unit cost".
- Greater risk aversion  $\rightarrow$  Further trade deviations  $\rightarrow$  Increased distortions

# Risk-Adjusted Pricing Equations

- FOCs of domestic price  $p_{ii}$  and export price  $p_{ki}$ :

$$\frac{\partial \mathbb{E}[\pi_i]}{\partial p_{ii}} - \frac{\gamma}{2} \frac{\partial \text{Var}(\pi_i)}{\partial p_{ii}} = 0, \quad \frac{\partial \mathbb{E}[\pi_i]}{\partial p_{ki}} - \frac{\gamma}{2} \frac{\partial \text{Var}(\pi_i)}{\partial p_{ki}} = 0 \quad (27)$$

- The domestic risk premium  $\psi_{ii}$  and the export risk premium  $\psi_{ki}$ :

$$\psi_{ii} = \gamma(1 - \sigma)\alpha s_i^M \sum_{j,l} \chi_{ij}^M u_{il} \sigma_{jl}^e, \quad \psi_{ki} = \gamma \sum_{j,l} \varepsilon_{ij}^{R_k} u_{il} \sigma_{jl}^e \quad (28)$$

- The domestic and export risk premia with the profit exposure factor  $\mathbf{u}_i$ :

$$\psi_{ii} = \gamma \phi_i^M (\vec{\chi}_i^M)^\top (\Sigma^e \mathbf{u}_i), \quad \psi_{ki} = \psi_{ii} + \gamma \phi_i^X (\Sigma^e \mathbf{u}_i)_k \quad (29)$$

where  $\phi_i^M = (1 - \sigma)\alpha s_i^M$  and  $\phi_i^X = \lambda\sigma + 1 - \lambda$  are sensitivity factors.

# Risk-Adjusted Import Allocation

- FOC of import shares under risk aversion:

$$\frac{\partial \mathbb{E}[C_{M,i}]}{\partial \chi_{ij}^M} + \gamma(\mathbf{d}_{ij}^M)^\top \Sigma^e \mathbf{u}_i = \lambda_M \quad (30)$$

- $d_{ij}^M \equiv \frac{\partial u_i^C}{\partial \chi_{ij}^M} \in \mathbb{R}^J$  is the marginal impact of import shares on cost exposure.
- The “effective unit sourcing cost” works as a shadow price:

$$\tilde{p}_{ij} \equiv p_{ij} + \Gamma_M \cdot \gamma(\mathbf{d}_{ij}^M)^\top \Sigma^e \mathbf{u}_i \quad (31)$$

where  $\Gamma^M > 0$  is the unit conversion constant.

- The import shares under risk aversion deviates from the risk-neutral shares:

$$\chi_{ij}^M = \frac{(\tilde{p}_{ij})^{1-\kappa}}{\sum_{j' \in \mathcal{J}} (\tilde{p}_{ij'})^{1-\kappa}} = \frac{(p_{ij} + \Gamma_M \gamma(\mathbf{d}_{ij}^M)^\top \Sigma^e \mathbf{u}_i)^{1-\kappa}}{\sum_{j'} (p_{ij'} + \Gamma_M \gamma(\mathbf{d}_{ij'}^M)^\top \Sigma^e \mathbf{u}_i)^{1-\kappa}} \quad (32)$$

# Linear Equation System under Risk Aversion

- The risk-averse pricing equation as:

$$A_p \Delta z + \gamma R_p \Sigma^e \Delta u = B_p \Delta s + C_p \Psi \quad (33)$$

- $\Delta s$ : the exogenous exchange rate shock.
  - $\Delta z$ : includes changes in endogenous variables.
  - $\Psi$ : level factors and other unmodeled shifts.
  - $R_p$ : risk-loading block (sensitivity to exposure changes)
- The net exchange rate exposure change  $\Delta u$  absorbs export price risk premium and import share adjustments:

$$\Delta u = T_u(\gamma)(N_z \Delta z + N_s \Delta s + N_\Psi \Psi) \quad (34)$$

- $N_z$ ,  $N_s$ , and  $N_\Psi$ : structural coefficients of exposure adjustments.
- The final linear equation system:

$$\underbrace{(A_z + \gamma R_p \Sigma^e T_u N_z)}_{A^*(\gamma)} \Delta z = \underbrace{(B_p - \gamma R_p \Sigma^e T_u N_s)}_{B^*(\gamma)} \Delta s + \underbrace{(C_p - \gamma R_p \Sigma^e T_u N_\psi)}_{C^*(\gamma)} \psi \quad (35)$$

# Metrics of Hedging Effectiveness

- Exposure-offset share (EOS)**

$$\text{EOS}_i = 1 - \frac{|\tilde{R}_i - \tilde{C}_i|}{|\tilde{R}_i| + |\tilde{C}_i|} = 1 - \frac{\|\mathbf{u}_i\|}{\|\mathbf{u}_i^R\| + \|\mathbf{u}_i^C\|} \text{hon} \quad (36)$$

- Variance-reduction ratio (VRR)**

$$\text{VRR}_i = \frac{2\text{Cov}(\tilde{R}_i, \tilde{C}_i)}{\text{Var}(\tilde{R}_i) + \text{Var}(\tilde{C}_i)} = \frac{2(\mathbf{u}_i^R)^\top \Sigma^e (\mathbf{u}_i^C)}{(\mathbf{u}_i^R)^\top \Sigma^e \mathbf{u}_i^R + (\mathbf{u}_i^C)^\top \Sigma^e \mathbf{u}_i^C} \in [-1, 1] \quad (37)$$

- Revenue-cost correlation ( $\rho^{RC}$ )**

$$\rho_i^{RC} = \frac{\text{Cov}(\tilde{R}_i, \tilde{C}_i)}{\sqrt{\text{Var}(\tilde{R}_i)\text{Var}(\tilde{C}_i)}} = \frac{\mathbf{u}_i^R{}^\top \Sigma^e \mathbf{u}_i^C}{\sqrt{[(\mathbf{u}_i^R)^\top \Sigma^e \mathbf{u}_i^R][(\mathbf{u}_i^C)^\top \Sigma^e \mathbf{u}_i^C]}} \in [0, 1] \quad (38)$$

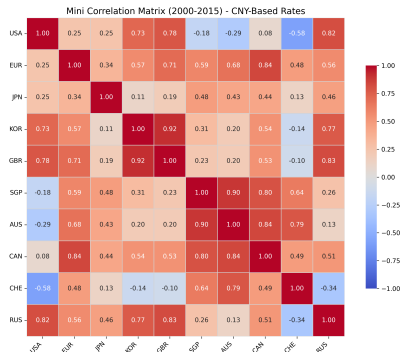
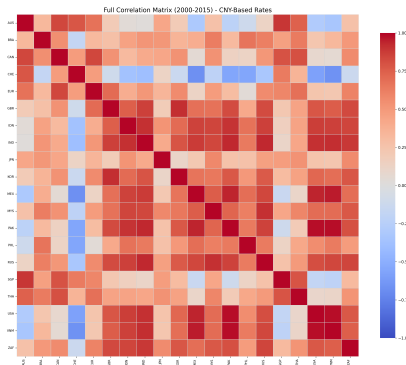
- Higher EOS/VRR/ $\rho^{RC} \rightarrow$  stronger hedging through trade linkages.

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# Estimation of Covariance Matrix

- Exchange rate covariance matrix  $\Sigma^e \in \mathbb{R}^{N \times N}$  is essential in structural model.
- Sample covariance matrix:  $\hat{\Sigma}_S = \frac{1}{T-1} \sum_{t=1}^T X_t X_t'$ 
  - $X_t = r_t - \frac{1}{T} \sum_{t=1}^T r_t$ : observed deviation from sample mean of log returns  $r_t$ .
  - Ledoit-Wolf shrinkage  $\hat{\Sigma}_{\text{LW}} = \delta F_{cc} + (1 - \delta) \hat{\Sigma}_S$



# Parametrization

Table: Parametrization

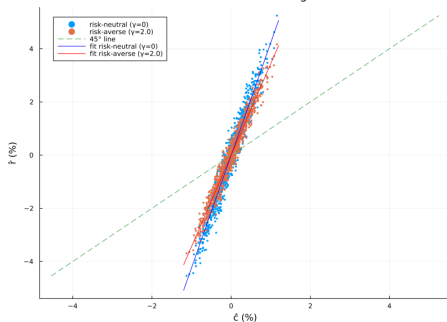
Parameter	Symbol	Value	Method & Source
Demand elasticity	$\sigma$	3.8	Oberfield and Raval (2021)
Output elasticity of materials	$\alpha$	0.6	Oberfield and Raval (2021)
PCP share	$\lambda$	0.95	Li, Ma and Xu (2015), <a href="#">Li, Lu and Zhao (2025)</a>
Elasticity of substitution between domestic and foreign inputs	$\epsilon$	4.0	Halpern, Koren and Szeidl (2015), Gopinath and Neiman (2014)
Elasticity of substitution between inputs from different origins	$\kappa$	3.0	Feenstra et al. (2018)
Risk aversion	$\gamma$	2.0	Chetty (2006) and calibration

Note: This table lists the parameter values assigned from literature and calibration.

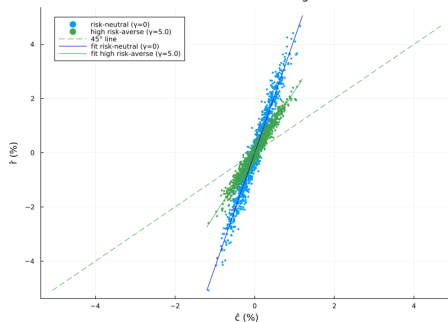
# Monte-Carlo Simulation: Revenue vs Cost

- I simulate 10000 exchange rate shocks  $\Delta e \sim \mathcal{N}(0, \hat{\Sigma})$  over 20 currencies.
- Revenue and cost changes are closer to the 45-degree line with higher  $\gamma$ .

Revenue vs Cost Changes



Revenue vs Cost Changes

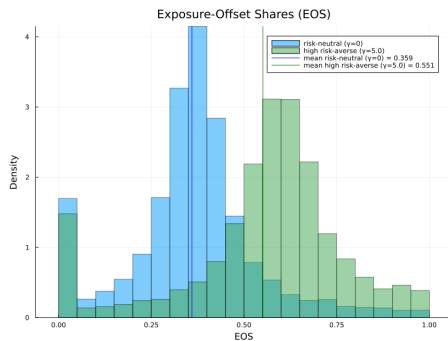
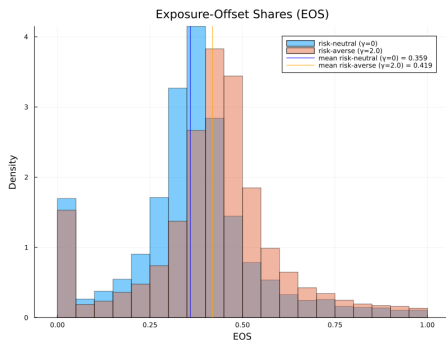


# Monte-Carlo Simulation: EOS Distribution

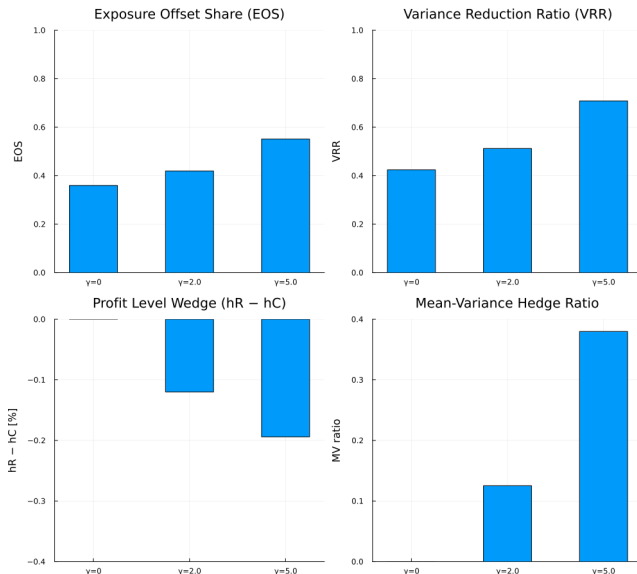
- Exposure-offset share (EOS)**

$$\text{EOS}_i^{MC} = 1 - \frac{\|\vec{a}_i^{MC} + \sum_k \vec{b}_{ik}^{MC} - \vec{c}_i^{MC}\|}{\|\vec{a}_i^{MC} + \sum_k \vec{b}_{ik}^{MC}\| + \|\vec{c}_i^{MC}\|}$$

- The distribution of EOS shifts to the right with higher risk aversion  $\gamma$ .

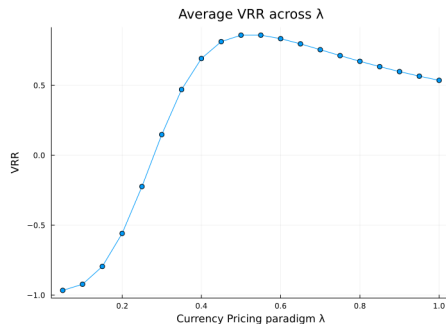
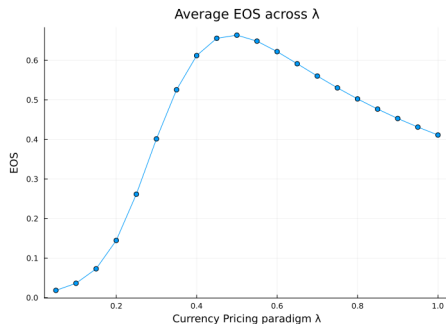


# Average Effectiveness and Cost of Natural Hedging



# Export Pricing Scheme: PCP vs LCP

- Export pricing paradigm  $\lambda \in [0, 1]$  (LCP=0, PCP=1).
- Better average natural hedging in a mixed PCP/LCP case.

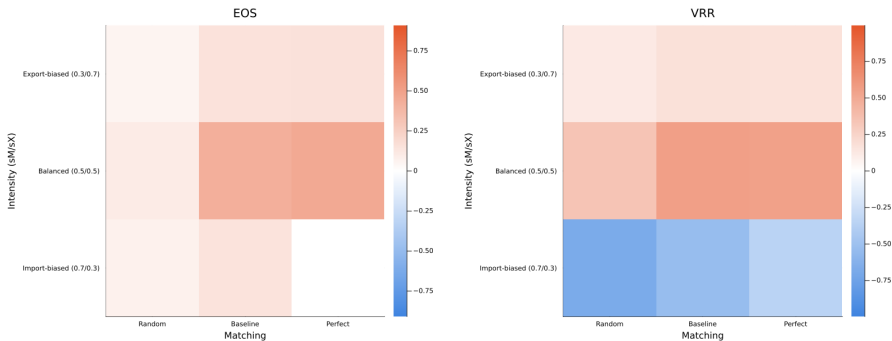


# Roadmap of Counterfactual Experiments

- Alternative initial trade structure
  - Balance of import and export intensities: import-biased ( $s^M > s^X$ ), balanced ( $s^M \approx s^X$ ), export-biased ( $s^M < s^X$ ).
  - Matching of import and export shares: random (no correlation  $\vec{\chi}^M$  and  $\vec{\chi}^X$ ), baseline ( $\vec{\chi}_0^M$  and  $\vec{\chi}_0^X$  from data), perfect ( $\vec{\chi}^M = \vec{\chi}^X$ ).
- Hypothetical exchange rate environments
  - Currency peg: fixed exchange rates with USD and the 20-currency basket.
  - Volatility amplification: global hikes (all elements in  $\Sigma^e \times 2$ ) and idiosyncratic hikes (only diagonal elements in  $\Sigma^e \times 2$ ).
  - Jump-mix risk (in Appendix): USD and EUR ( $p = 10\%$  and  $|J| = 20\%$ ).

# Counterfactual Trade Structure

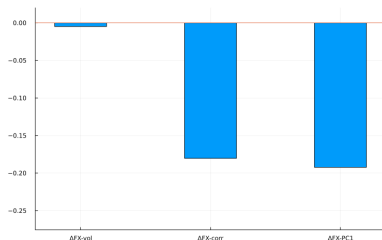
- $3 \times 3$  (export-biased, balanced, import-biased)  $\times$  (random, baseline, perfect)



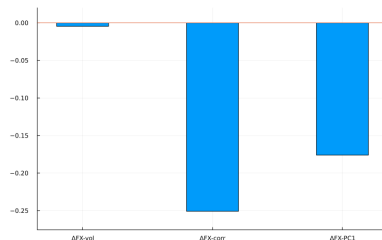
- Two-way traders with balanced import and export and perfect country matching can hedge most of exchange rate risk!

# Counterfactual ER Environment: Currency Peg

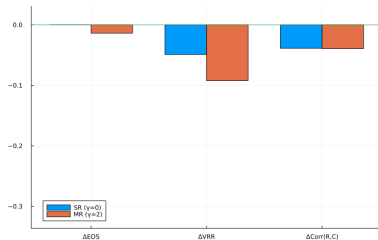
FX environment  $\Delta$  (vs baseline) — USD peg ( $\kappa=0.00$ )



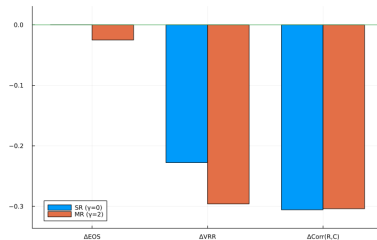
FX environment  $\Delta$  (vs baseline) — Basket peg ( $\kappa=0.30$ )



Natural hedge  $\Delta$  (vs baseline) — USD peg ( $\kappa=0.00$ )

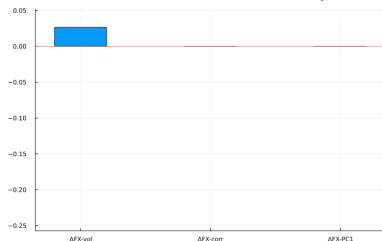


Natural hedge  $\Delta$  (vs baseline) — Basket peg ( $\kappa=0.30$ )

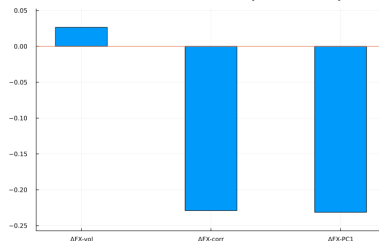


# Counterfactual ER Environment: Volatility Amplification

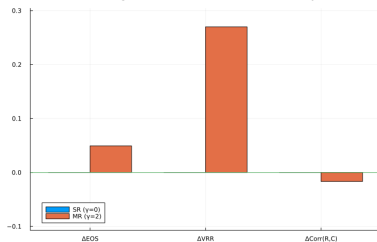
FX environment  $\Delta$  (vs baseline) — Global volatility  $\times 2.00$



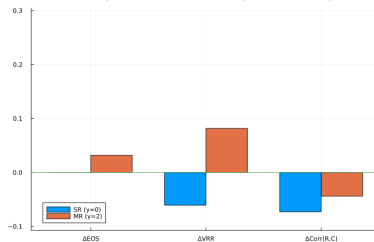
FX environment  $\Delta$  (vs baseline) — Idiosyncratic volatility  $\times 2.00$



Natural hedge  $\Delta$  (vs baseline) — Global volatility  $\times 2.00$



Natural hedge  $\Delta$  (vs baseline) — Idiosyncratic volatility  $\times 2.00$



# Outline

- 1 Introduction
- 2 Empirical Facts
- 3 Model
- 4 Quantitative Analysis
- 5 Conclusion**

# Conclusion

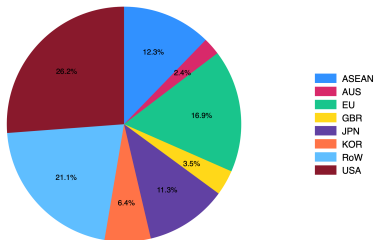
- This paper shows how **import-export linkages** shapes firms' responses to exchange rate fluctuations.
- I have provided empirical evidence showing that two-way traders exhibit lower sensitivity to exchange rates, as: (1) exchange rates exert opposing effects on revenues and costs; (2) shocks in different currencies tend to offset one another.
- I develop a tractable trade model with pricing-to-market + global sourcing + nominal price wedge from exchange rates.
- Firms face profit-variance trade-off under exchange rate uncertainty → **natural hedging** with **pricing and sourcing** decisions.
- The structural model allows for testing hedging effectiveness in counterfactual initial trade structure and exchange rate environments.
- **Implication:** The import-export linkage is crucial for (firms) managing exchange rate risk and (governments) making trade and monetary policies, especially in emerging markets, where financial hedging is limited.

# More Research and Future Plan

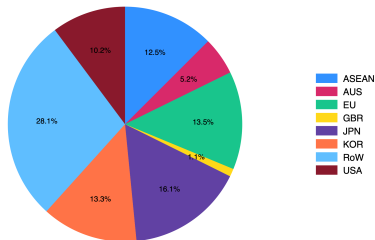
- My research pipeline: **Global Shocks** vs **Firm Responses**
- Previous research papers
  - Li, Yao Amber, Lingfei Lu, and Tengyu Zhao. "Exchange rate pass-through and importers' credit constraints: Evidence from China." *Journal of Economic Behavior & Organization* 236 (2025): 107044.
  - Li, Yao Amber, Lingfei Lu, Shang-Jin Wei and Jingbo Yao. "The Spill-back and Spillover Effects of US Monetary Policy: Evidence on an International Cost Channel." No. w33811. National Bureau of Economic Research, 2025.
- Future research plan:
  - A Unified Framework of Global Sourcing with Two-Sided Bargaining:
  - Multi-Layer Trade Network and Exchange Rate Dynamics

# Motivating Facts: Top Markets and Origins

China's top export markets by value (2000-2015)



China's top import origins by value (2000-2015)



# Natural Hedging vs Financial Hedging

## Summary

- In EMDEs, corporate use of FX derivatives is limited; instruments are short-tenor; access is constrained by actual-needs rules, documentation, and margin requirements.
- As a result, natural hedging (matching currency in operations and balance sheets) is often the only scalable and affordable risk-management channel for trade-exposed firms.

## China: limited take-up and segmentation

- Corporate hedge ratios remain far below full coverage.
- Actual-needs requirements and CNY–CNH market segmentation create pricing and liquidity frictions.

## Policy and access frictions across EMDEs

- India: documentation of underlying exposure, position limits, designated dealers.
- Indonesia: mandatory hedging ratios for firms with FX debt; liquidity and rating tests.
- Malaysia, Philippines, Thailand: restrictions on NDFs and non-resident positions; coterminous tenors with underlying.

## Market depth, tenor, and transaction costs

- Wider bid–ask spreads in APAC EM FX and limited availability beyond one year.
- Shorter available tenors relative to major currencies.

## Funding frictions and the CIP basis

- Persistent deviations from CIP in EMDEs increase hedge costs, especially in stress.

## Collateral and operational barriers

- ISDA/CSA documentation, daily margining, and collateral needs tie up liquidity.
- Negotiation and onboarding timelines are lengthy, posing barriers for SMEs.

## Case beyond Asia

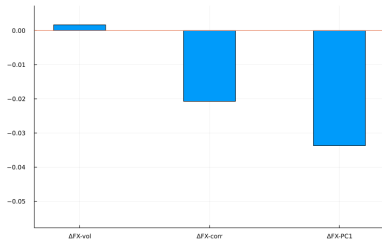
- Public and MDB-supported programs to extend longer-dated and cheaper hedges indicate market scarcity at long maturities.

## Implications

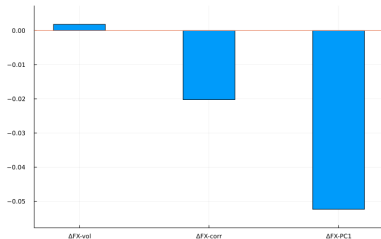
- For EMDE exporters and importers, financial hedges are often incomplete and costly.
- Natural hedging now becomes the ideal substituting approach under binding frictions.

# ER Environment: Jump-mix Risk

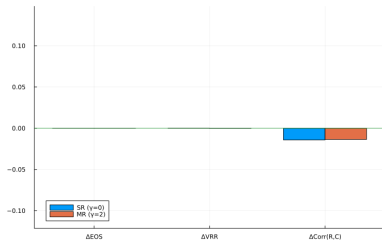
FX environment  $\Delta$  (vs baseline) — Jump risk (USD):  $p=10\%$ ,  $J=20\%$



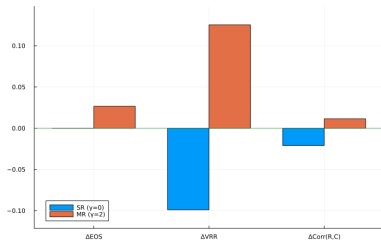
FX environment  $\Delta$  (vs baseline) — Jump risk (EUR):  $p=10\%$ ,  $J=20\%$



Natural hedge  $\Delta$  (vs baseline) — Jump risk (USD):  $p=10\%$ ,  $J=20\%$



Natural hedge  $\Delta$  (vs baseline) — Jump risk (EUR):  $p=10\%$ ,  $J=20\%$



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